

## TC74VCXR2245FT, TC74VCXR2245FK, TC74VCXR2245FTG

### Low-Voltage Octal Bus Transceiver with 3.6-V Tolerant Inputs and Outputs

The TC74VCXR2245 is a high-performance CMOS octal bus transceiver. Designed for use in 1.8-V, 2.5-V or 3.3-V systems, it achieves high-speed operation while maintaining the CMOS low power dissipation.

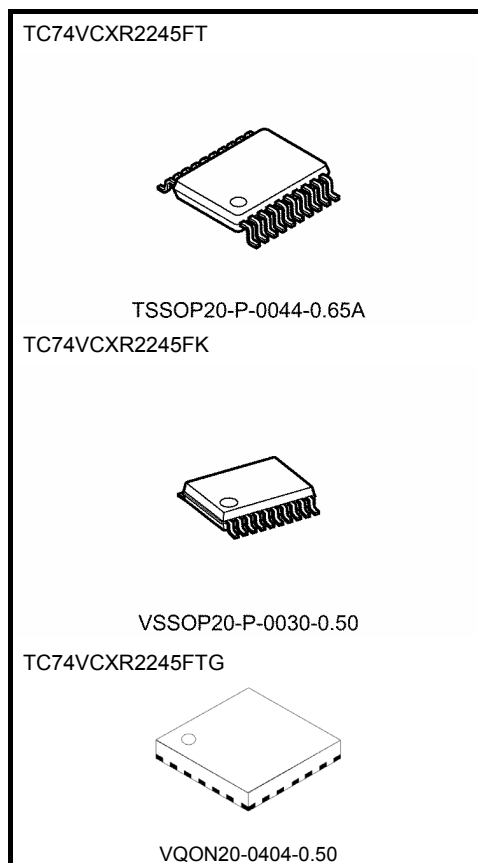
It is also designed with overvoltage tolerant inputs and outputs up to 3.6 V.

The direction of data transmission is determined by the level of the DIR inputs. The  $\overline{OE}$  inputs can be used to disable the device so that the busses are effectively isolated. The 26- $\Omega$  series resistor helps reducing output overshoot and undershoot without external resistor.

All inputs are equipped with protection circuits against static discharge.

#### Features (Note 1)

- 26- $\Omega$  series resistors on outputs
- Low-voltage operation:  $V_{CC} = 1.8$  to 3.6 V
- High-speed operation:  $t_{pd} = 4.4$  ns (max) ( $V_{CC} = 3.0$  to 3.6 V)  
                                   :  $t_{pd} = 5.6$  ns max ( $V_{CC} = 2.3$  to 2.7 V)  
                                   :  $t_{pd} = 9.8$  ns (max) ( $V_{CC} = 1.8$  V)
- Output current:  $I_{OH}/I_{OL} = \pm 12$  mA (min) ( $V_{CC} = 3.0$  V)  
                                   :  $I_{OH}/I_{OL} = \pm 8$  mA (min) ( $V_{CC} = 2.3$  V)  
                                   :  $I_{OH}/I_{OL} = \pm 4$  mA (min) ( $V_{CC} = 1.8$  V)
- Latch-up performance:  $-300$  mA
- ESD performance: Machine model  $\geq \pm 200$  V  
                                   Human body model  $\geq \pm 2000$  V
- Package: TSSOP  
                   VSSOP (US)  
                   VQON
- 3.6-V tolerant function and power-down protection provided on all inputs and outputs

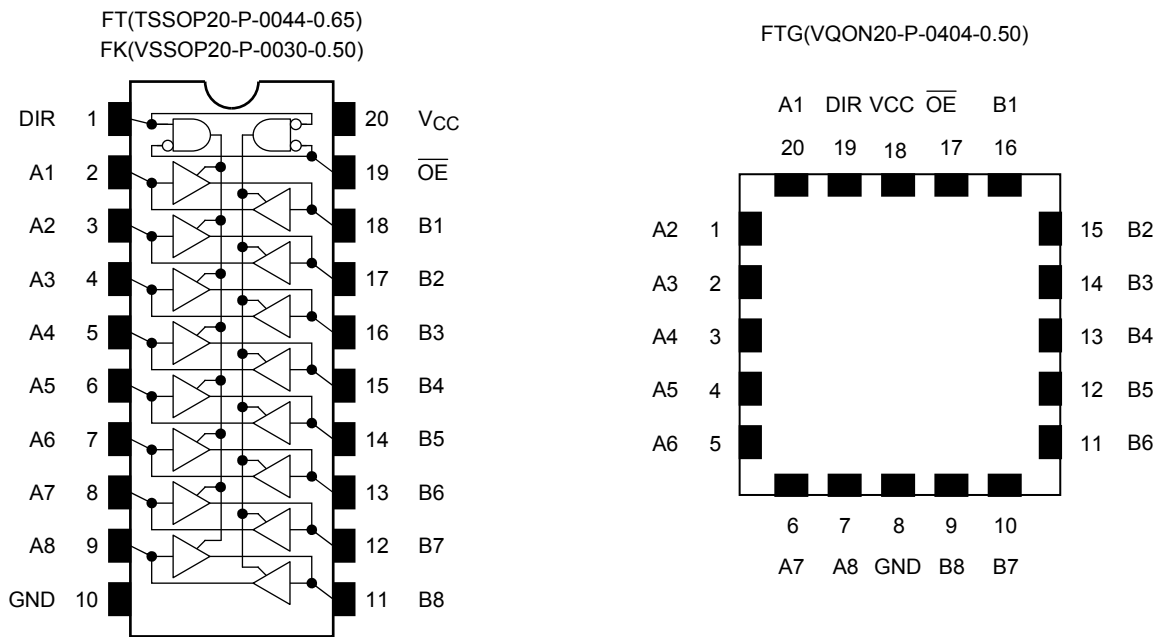


#### Weight

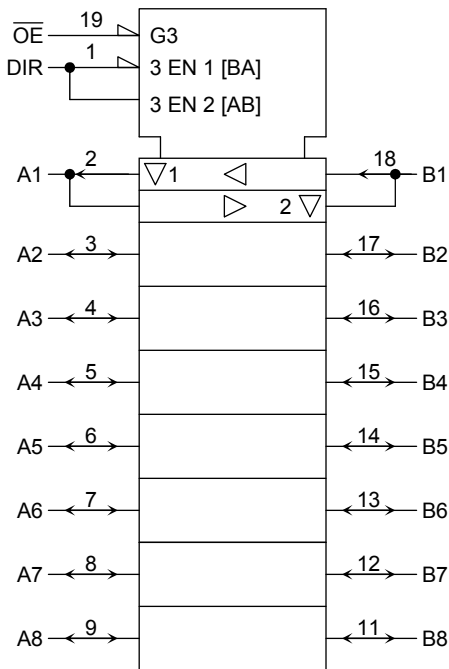
|                      |                  |
|----------------------|------------------|
| TSSOP20-P-0044-0.65A | : 0.08 g (typ.)  |
| VSSOP20-P-0030-0.50  | : 0.03 g (typ.)  |
| VQON20-P-0404-0.50   | : 0.0145g (typ.) |

Note 1: When mounting VQON package, the type of recommended flux is RA or RMA.

Pin Assignment (top view)



IEC Logic Symbol



Truth Table

| Inputs          |     | Outputs | Function |        |
|-----------------|-----|---------|----------|--------|
| $\overline{OE}$ | DIR |         | A-Bus    | B-Bus  |
| L               | L   | A = B   | OUTPUT   | INPUT  |
| L               | H   | B = A   | INPUT    | OUTPUT |
| H               | X   | Z       | Z        |        |

X: Don't care

Z: High impedance

## Absolute Maximum Ratings (Note 1)

| Characteristics                             | Symbol           | Rating                             | Unit |
|---|------------------|------------------------------------|------|
| Power supply voltage                        | $V_{CC}$         | -0.5 to 4.6                        | V    |
| DC input voltage<br>(DIR, $\overline{OE}$ ) | $V_{IN}$         | -0.5 to 4.6                        | V    |
| DC bus I/O voltage                          | $V_{I/O}$        | -0.5 to 4.6 (Note 2)               | V    |
|   |                  | -0.5 to $V_{CC} + 0.5$<br>(Note 3) |      |
| Input diode current                         | $I_{IK}$         | -50                                | mA   |
| Output diode current                        | $I_{OK}$         | $\pm 50$ (Note 4)                  | mA   |
| DC output current                           | $I_{OUT}$        | $\pm 50$                           | mA   |
| Power dissipation                           | $P_D$            | 180                                | mW   |
| DC $V_{CC}$ /ground current                 | $I_{CC}/I_{GND}$ | $\pm 100$                          | mA   |
| Storage temperature                         | $T_{stg}$        | -65 to 150                         | °C   |

Note 1: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction.

Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.

Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook ("Handling Precautions"/"Derating Concept and Methods") and individual reliability data (i.e. reliability test report and estimated failure rate, etc.).

Note 2: OFF state

Note 3: High or low state.  $I_{OUT}$  absolute maximum rating must be observed.

Note 4:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

## Operating Ranges (Note 1)

| Characteristics                          | Symbol          | Rating                 | Unit |
|--|-----------------|------------------------|------|
| Power supply voltage                     | $V_{CC}$        | 1.8 to 3.6             | V    |
|  |                 | 1.2 to 3.6 (Note 2)    |      |
| Input voltage<br>(DIR, $\overline{OE}$ ) | $V_{IN}$        | -0.3 to 3.6            | V    |
| Bus I/O voltage                          | $V_{I/O}$       | 0 to 3.6 (Note 3)      | V    |
|  |                 | 0 to $V_{CC}$ (Note 4) |      |
| Output current                           | $I_{OH}/I_{OL}$ | $\pm 12$ (Note 5)      | mA   |
|  |                 | $\pm 8$ (Note 6)       |      |
|  |                 | $\pm 4$ (Note 7)       |      |
| Operating temperature                    | $T_{opr}$       | -40 to 85              | °C   |
| Input rise and fall time                 | $dt/dv$         | 0 to 10 (Note 8)       | ns/V |

Note 1: The operating ranges must be maintained to ensure the normal operation of the device. Unused inputs and bus inputs must be tied to either  $V_{CC}$  or GND. Please connect both bus inputs and the bus outputs with  $V_{CC}$  or GND when the I/O of the bus terminal changes by the function. In this case, please note that the output is not short-circuited.

Note 2: Data retention only

Note 3: OFF state

Note 4: High or low state

Note 5:  $V_{CC} = 3.0$  to  $3.6$  V

Note 6:  $V_{CC} = 2.3$  to  $2.7$  V

Note 7:  $V_{CC} = 1.8$  V

Note 8:  $V_{IN} = 0.8$  to  $2.0$  V,  $V_{CC} = 3.0$  V

**Electrical Characteristics**
**DC Characteristics ( $T_a = -40$  to  $85^\circ\text{C}$ ,  $2.7\text{ V} < V_{CC} \leq 3.6\text{ V}$ )**

| Characteristics                       |         | Symbol           | Test Condition  |                           | V <sub>CC</sub> (V) | Min                   | Max   | Unit |
|---------------------------------------|---------|------------------|---|---------------------------|---------------------|-----------------------|-------|------|
| Input voltage                         | H-level | V <sub>IH</sub>  | —   |                           | 2.7 to 3.6          | 2.0                   | —     | V    |
|                                       | L-level | V <sub>IL</sub>  | —   |                           | 2.7 to 3.6          | —                     | 0.8   |      |
| Output voltage                        | H-level | V <sub>OH</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                  | I <sub>OH</sub> = −100 μA | 2.7 to 3.6          | V <sub>CC</sub> − 0.2 | —     | V    |
|                                       |         |                  |   | I <sub>OH</sub> = −6 mA   | 2.7                 | 2.2                   | —     |      |
|                                       |         |                  |   | I <sub>OH</sub> = −8 mA   | 3.0                 | 2.4                   | —     |      |
|                                       |         |                  |   | I <sub>OH</sub> = −12 mA  | 3.0                 | 2.2                   | —     |      |
|                                       | L-level | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                  | I <sub>OL</sub> = 100 μA  | 2.7 to 3.6          | —                     | 0.2   |      |
|                                       |         |                  |   | I <sub>OL</sub> = 6 mA    | 2.7                 | —                     | 0.4   |      |
|                                       |         |                  |   | I <sub>OL</sub> = 8 mA    | 3.0                 | —                     | 0.55  |      |
|                                       |         |                  |   | I <sub>OL</sub> = 12 mA   | 3.0                 | —                     | 0.8   |      |
| Input leakage current                 |         | I <sub>IN</sub>  | V <sub>IN</sub> = 0 to 3.6 V  |                           | 2.7 to 3.6          | —                     | ±5.0  | μA   |
| 3-state output OFF state current      |         | I <sub>OZ</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>V <sub>OUT</sub> = 0 to 3.6 V |                           | 2.7 to 3.6          | —                     | ±10.0 | μA   |
| Power-off leakage current             |         | I <sub>OFF</sub> | V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V                                       |                           | 0                   | —                     | 10.0  | μA   |
| Quiescent supply current              |         | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND  |                           | 2.7 to 3.6          | —                     | 20.0  | μA   |
|                                       |         |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V                       |                           | 2.7 to 3.6          | —                     | ±20.0 |      |
| Increase in I <sub>CC</sub> per input |         | ΔI <sub>CC</sub> | V <sub>IH</sub> = V <sub>CC</sub> − 0.6 V (per input)                                 |                           | 2.7 to 3.6          | —                     | 750   |      |

**DC Characteristics ( $T_a = -40$  to  $85^\circ\text{C}$ ,  $2.3\text{ V} \leq V_{CC} \leq 2.7\text{ V}$ )**

| Characteristics                  |         | Symbol           | Test Condition  |                           | V <sub>CC</sub> (V) | Min                   | Max   | Unit |
|----------------------------------|---------|------------------|---|---------------------------|---------------------|-----------------------|-------|------|
| Input voltage                    | H-level | V <sub>IH</sub>  | —   |                           | 2.3 to 2.7          | 1.6                   | —     | V    |
|                                  | L-level | V <sub>IL</sub>  | —   |                           | 2.3 to 2.7          | —                     | 0.7   |      |
| Output voltage                   | H-level | V <sub>OH</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                  | I <sub>OH</sub> = −100 μA | 2.3 to 2.7          | V <sub>CC</sub> − 0.2 | —     | V    |
|                                  |         |                  |   | I <sub>OH</sub> = −4 mA   | 2.3                 | 2.0                   | —     |      |
|                                  |         |                  |   | I <sub>OH</sub> = −6 mA   | 2.3                 | 1.8                   | —     |      |
|                                  |         |                  |   | I <sub>OH</sub> = −8 mA   | 2.3                 | 1.7                   | —     |      |
|                                  | L-level | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                  | I <sub>OL</sub> = 100 μA  | 2.3 to 2.7          | —                     | 0.2   |      |
|                                  |         |                  |   | I <sub>OL</sub> = 6 mA    | 2.3                 | —                     | 0.4   |      |
|                                  |         |                  |   | I <sub>OL</sub> = 8 mA    | 2.3                 | —                     | 0.6   |      |
| Input leakage current            |         | I <sub>IN</sub>  | V <sub>IN</sub> = 0 to 3.6 V  |                           | 2.3 to 2.7          | —                     | ±5.0  | μA   |
| 3-state output OFF state current |         | I <sub>OZ</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>V <sub>OUT</sub> = 0 to 3.6 V |                           | 2.3 to 2.7          | —                     | ±10.0 | μA   |
| Power-off leakage current        |         | I <sub>OFF</sub> | V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V                                       |                           | 0                   | —                     | 10.0  | μA   |
| Quiescent supply current         |         | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND  |                           | 2.3 to 2.7          | —                     | 20.0  | μA   |
|                                  |         |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V                       |                           | 2.3 to 2.7          | —                     | ±20.0 |      |

## DC Characteristics (Ta = -40 to 85°C, 1.8 V ≤ VCC < 2.3 V)

| Characteristics                  |         | Symbol           | Test Condition  |                           | Min                 | Max                   | Unit                  |    |
|----------------------------------|---------|------------------|---|---------------------------|---------------------|-----------------------|-----------------------|----|
|                                  |         |                  |   |                           | V <sub>CC</sub> (V) |                       |                       |    |
| Input voltage                    | H-level | V <sub>IH</sub>  | —   |                           | 1.8 to 2.3          | 0.7 × V <sub>CC</sub> | —                     | V  |
|                                  | L-level | V <sub>IL</sub>  | —   |                           | 1.8 to 2.3          | —                     | 0.2 × V <sub>CC</sub> |    |
| Output voltage                   | H-level | V <sub>OH</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                  | I <sub>OH</sub> = −100 μA | 1.8                 | V <sub>CC</sub> − 0.2 | —                     | V  |
|                                  |         |                  |   | I <sub>OH</sub> = −4 mA   | 1.8                 | 1.4                   | —                     |    |
|                                  | L-level | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                  | I <sub>OL</sub> = 100 μA  | 1.8                 | —                     | 0.2                   |    |
|                                  |         |                  |   | I <sub>OL</sub> = 4 mA    | 1.8                 | —                     | 0.3                   |    |
| Input leakage current            |         | I <sub>IN</sub>  | V <sub>IN</sub> = 0 to 3.6 V  |                           | 1.8                 | —                     | ±5.0                  | μA |
| 3-state output OFF state current |         | I <sub>OZ</sub>  | V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub><br>V <sub>OUT</sub> = 0 to 3.6 V |                           | 1.8                 | —                     | ±10.0                 | μA |
| Power-off leakage current        |         | I <sub>OFF</sub> | V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V                                       |                           | 0                   | —                     | 10.0                  | μA |
| Quiescent supply current         |         | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND  |                           | 1.8                 | —                     | 20.0                  | μA |
|                                  |         |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V                       |                           | 1.8                 | —                     | ±20.0                 |    |

## AC Characteristics (Ta = -40 to 85°C, input: t<sub>r</sub> = t<sub>f</sub> = 2.0 ns, C<sub>L</sub> = 30 pF, R<sub>L</sub> = 500 Ω) (Note 1)

| Characteristics             |  | Symbol             | Test Condition |           | Min | Max | Unit |
|-----------------------------|--|--------------------|----------------|-----------|-----|-----|------|
|                             |  |                    |                |           |     |     |      |
| Propagation delay time      | t <sub>pLH</sub><br>t <sub>pHL</sub>   | Figure 1, Figure 2 |                | 1.8       | 1.5 | 9.8 | ns   |
|                             |  |                    |                | 2.5 ± 0.2 | 0.8 | 5.6 |      |
|                             |  |                    |                | 3.3 ± 0.3 | 0.6 | 4.4 |      |
| 3-state output enable time  | t <sub>pZL</sub><br>t <sub>pZH</sub>   | Figure 1, Figure 3 |                | 1.8       | 1.5 | 9.8 | ns   |
|                             |  |                    |                | 2.5 ± 0.2 | 0.8 | 6.6 |      |
|                             |  |                    |                | 3.3 ± 0.3 | 0.6 | 5.0 |      |
| 3-state output disable time | t <sub>pLZ</sub><br>t <sub>pHZ</sub>   | Figure 1, Figure 3 |                | 1.8       | 1.5 | 8.5 | ns   |
|                             |  |                    |                | 2.5 ± 0.2 | 0.8 | 4.7 |      |
|                             |  |                    |                | 3.3 ± 0.3 | 0.6 | 4.2 |      |
| Output to output skew       | t <sub>osLH</sub><br>t <sub>osHL</sub> | (Note 2)           |                | 1.8       | —   | 0.5 | ns   |
|                             |  |                    |                | 2.5 ± 0.2 | —   | 0.5 |      |
|                             |  |                    |                | 3.3 ± 0.3 | —   | 0.5 |      |

Note 1: For C<sub>L</sub> = 50 pF, add approximately 300 ps to the AC maximum specification.

Note 2: Parameter guaranteed by design.

(t<sub>osLH</sub> = |t<sub>pLHm</sub> - t<sub>pLHn</sub>|, t<sub>osHL</sub> = |t<sub>pHLm</sub> - t<sub>pHLn</sub>|)

## Dynamic Switching Characteristics (Ta = 25°C, input: tr = tf = 2.0 ns, CL = 30 pF)

| Characteristics                  | Symbol | Test Condition  | VCC (V) | Typ.  | Unit |
|----------------------------------|--------|---|---------|-------|------|
|                                  |        |   |         |       |      |
| Quiet output maximum dynamic VOL | VOLP   | V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note) | 1.8     | 0.15  | V    |
|                                  |        | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note) | 2.5     | 0.25  |      |
|                                  |        | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note) | 3.3     | 0.35  |      |
| Quiet output minimum dynamic VOL | VOLV   | V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note) | 1.8     | -0.15 | V    |
|                                  |        | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note) | 2.5     | -0.25 |      |
|                                  |        | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note) | 3.3     | -0.35 |      |
| Quiet output minimum dynamic VOH | VOHV   | V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note) | 1.8     | 1.55  | V    |
|                                  |        | V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note) | 2.5     | 2.05  |      |
|                                  |        | V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note) | 3.3     | 2.65  |      |

Note: Parameter guaranteed by design.

## Capacitive Characteristics (Ta = 25°C)

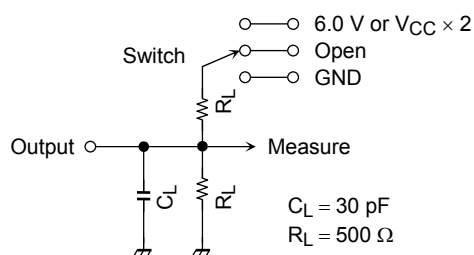
| Characteristics               | Symbol           | Test Condition                  | VCC (V)       | Typ. | Unit |
|-------------------------------|------------------|---------------------------------|---------------|------|------|
|                               |                  |                                 |               |      |      |
| Input capacitance             | C <sub>IN</sub>  | DIR, $\overline{\text{OE}}$     | 1.8, 2.5, 3.3 | 6    | pF   |
| Bus I/O capacitance           | C <sub>I/O</sub> | An, Bn                          | 1.8, 2.5, 3.3 | 7    | pF   |
| Power dissipation capacitance | C <sub>PD</sub>  | f <sub>IN</sub> = 10 MHz (Note) | 1.8, 2.5, 3.3 | 20   | pF   |

Note: C<sub>PD</sub> is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

Average operating current can be obtained by the equation:

$$I_{CC(\text{opr})} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/8 \text{ (per bit)}$$

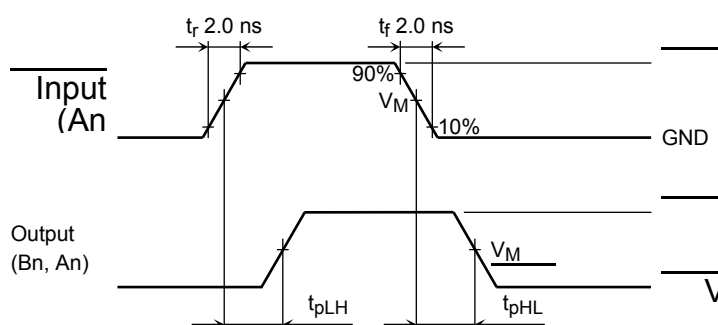
## AC Test Circuit



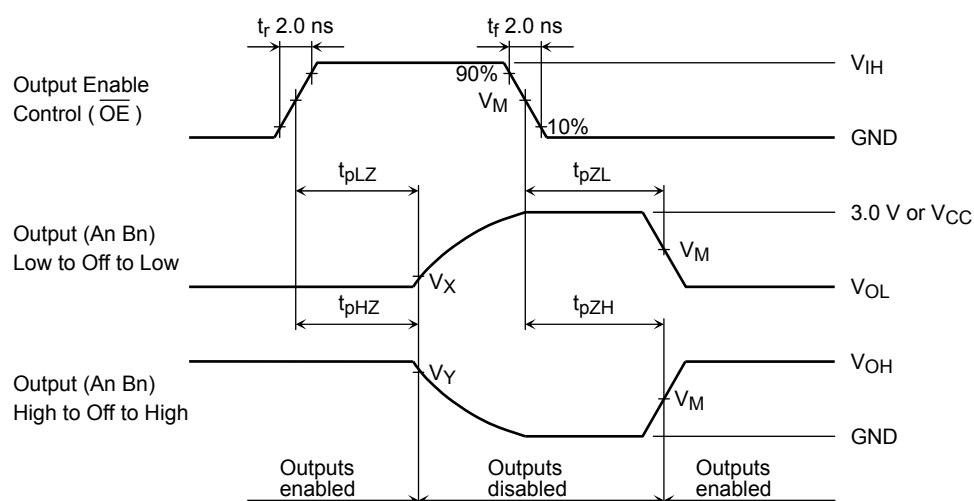
| Parameter                           | Switch   |
|-------------------------------------|--|
| t <sub>pLH</sub> , t <sub>pHL</sub> | Open   |
| t <sub>pLZ</sub> , t <sub>pZL</sub> | 6.0 V @V <sub>CC</sub> = 3.3 ± 0.3 V<br>VCC × 2 @V <sub>CC</sub> = 2.5 ± 0.2 V<br>@V <sub>CC</sub> = 1.8 V |
| t <sub>pHZ</sub> , t <sub>pZH</sub> | GND  |

Figure 1

## AC Waveform



**Figure 2**  $t_{PLH}$ ,  $t_{PHL}$



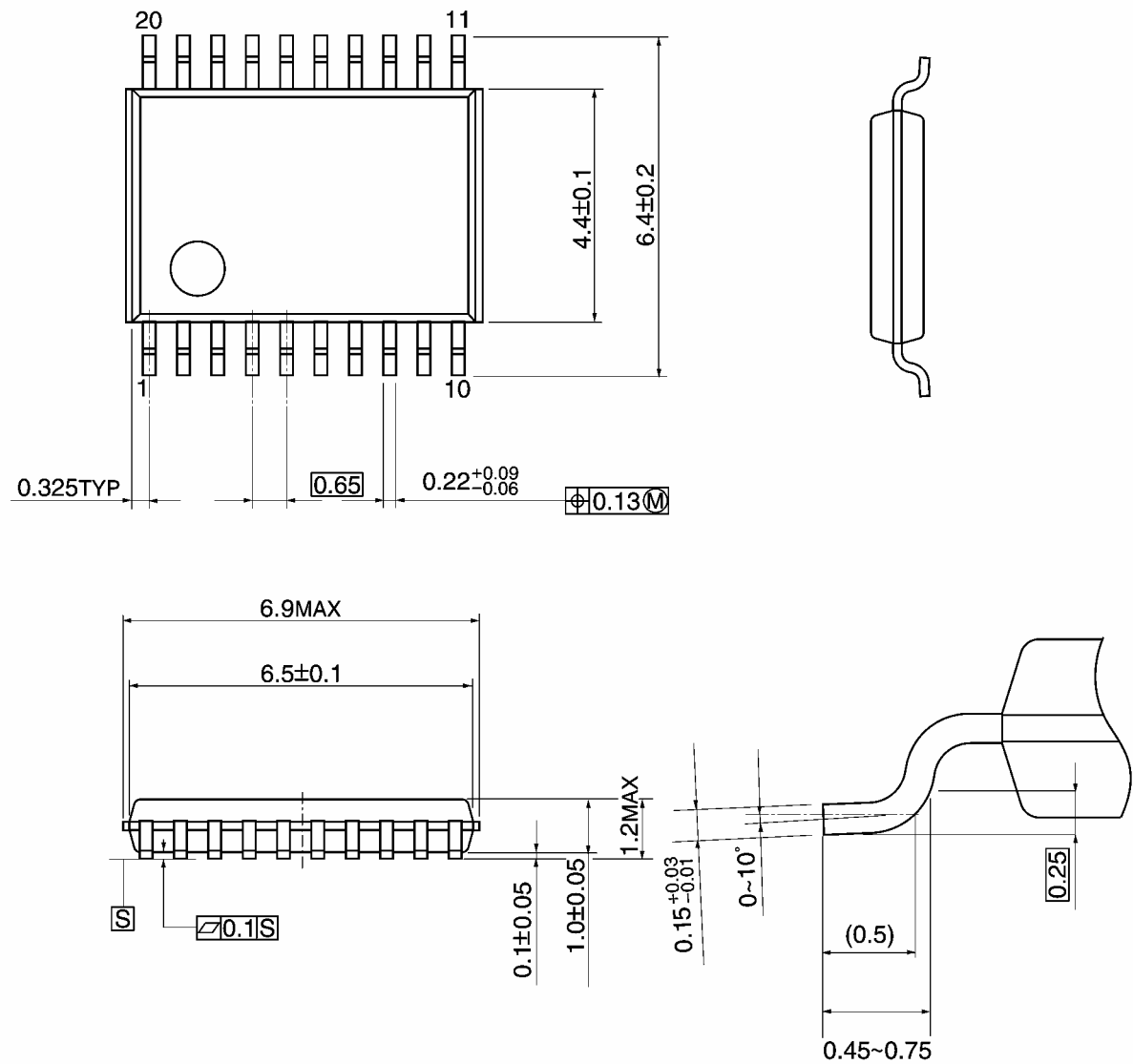
**Figure 3**  $t_{PLZ}$ ,  $t_{PHZ}$ ,  $t_{PZL}$ ,  $t_{PZH}$

| Symbol   | $V_{CC}$                 |                           |                           |
|----------|--------------------------|---------------------------|---------------------------|
|          | $3.3 \pm 0.3 \text{ V}$  | $2.5 \pm 0.2 \text{ V}$   | $1.8 \text{ V}$           |
| $V_{IH}$ | $2.7 \text{ V}$          | $V_{CC}$                  | $V_{CC}$                  |
| $V_M$    | $1.5 \text{ V}$          | $V_{CC}/2$                | $V_{CC}/2$                |
| $V_X$    | $V_{OL} + 0.3 \text{ V}$ | $V_{OL} + 0.15 \text{ V}$ | $V_{OL} + 0.15 \text{ V}$ |
| $V_Y$    | $V_{OH} - 0.3 \text{ V}$ | $V_{OH} - 0.15 \text{ V}$ | $V_{OH} - 0.15 \text{ V}$ |

Package Dimensions

TSSOP20-P-0044-0.65A

Unit: mm



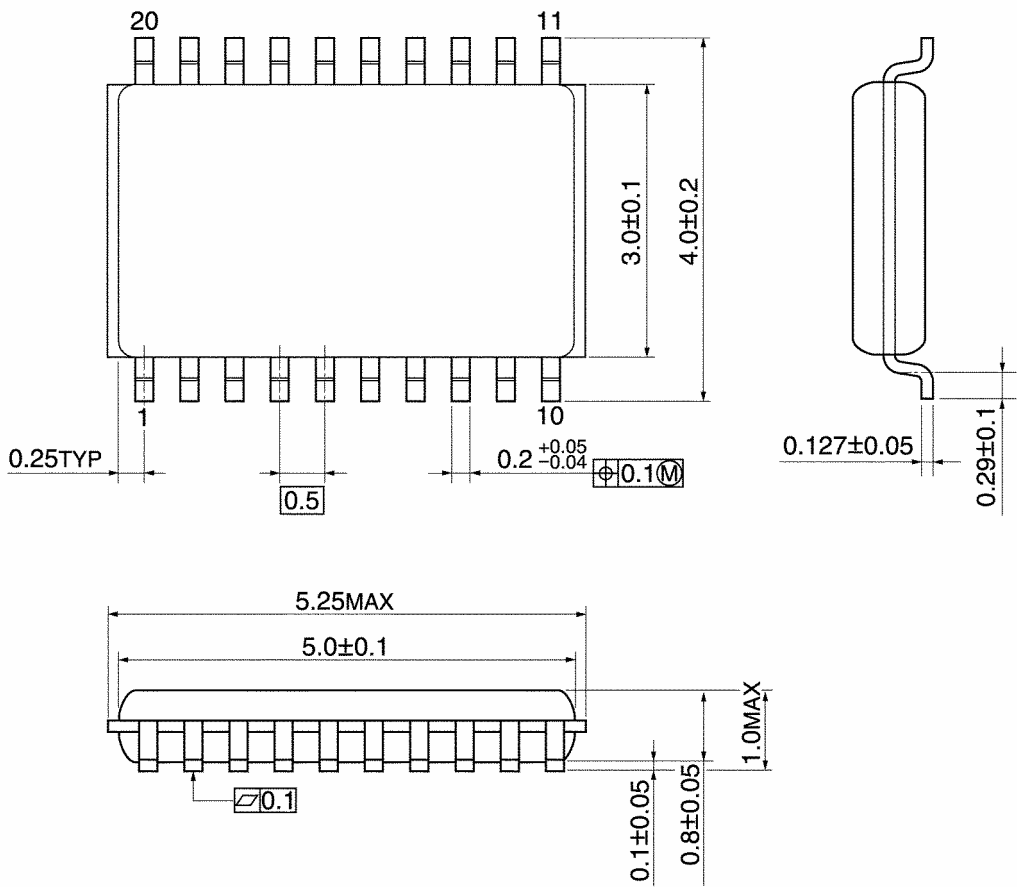
Weight: 0.08 g (typ.)



Package Dimensions

VSSOP20-P-0030-0.50

Unit: mm



Weight: 0.03 g (typ.)

VQON20-P-0404-0.50

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2007-10-19

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20070701-EN

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